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ABSTRACT

The purpose of this report is to document changes in U.S. mathematics achievement by reviewing national trend studies, college admissions examinations, and advanced placement tests. This report examined this quantitative research literature to determine trends in mathematics achievement of various social groups defined along lines of race, class, gender, ethnicity, and language proficiency. The findings of this review indicate that over the last 15 years all demographic groups have improved in mathematics achievement. Moreover, the mathematics achievement gap is slowly closing between white students and students of color. Males tended to outperform females on standardized measures; however, gender differences were small and generally not significant. Consistent with past reviews of mathematics achievement, coursetaking was a powerful variable, often resulting in similar achievement gains across diverse groups. This finding has serious implications for equity-related policy. (Author)

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Research Monograph No. 4

Race, SES, Gender, and Language Proficiency Trends in Mathematics Achievement: An Update

William F. Tate IV

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Research Monograph No. 4

Race, SES, Gender, and Language Proficiency Trends in Mathematics Achievement: An Update

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Abstract

The purpose of this report is to document changes in U.S. mathematics achievement by reviewing national trend studies, college admissions examinations, and advanced placement tests. This report examined this quantitative research literature to determine trends in mathematics achievement of various social groups defined along lines of race, class, gender, ethnicity, and language proficiency. The findings of this review indicate that over the last 15 years all demographic groups have improved in mathematics achievement. Moreover, the mathematics achievement gap is slowly closing between white students and students of color. Males tended to outperform females on standardized measures; however, gender differences were small and generally not significant. Consistent with past reviews of mathematics achievement, coursetaking was a powerful variable, often resulting in similar achievement gains across diverse groups. This finding has serious implications for equity-related policy.

The *Curriculum and Evaluation Standards for School Mathematics* and *Professional Standards for Teaching Mathematics* together provide a vision of mathematical goals that have been adopted by a large majority of state departments of education in the United States (Massell, 1994; NCTM, 1989, 1991). In support of these two documents, the philosophical background of the *Assessment Standards for School Mathematics* (NCTM, 1995) stated:

> This vision, based on the assumption that all students are capable of learning mathematics, is at the heart of the NCTM's reform effort. . . . Today, the mathematical development of each child in a diverse multicultural society must be valued. Assessment procedures must no longer deny students the opportunity to learn important mathematics. Instead, assessment should be a means of fostering growth toward high expectations. To do otherwise represents a waste of potential. (p. 1)

Consistent with the vision that all students can learn mathematics, *The National Education Goals Report: Building a Nation of Learners* (National Education Goals Panel,1995) called for the mathematics performance of all students at the elementary and secondary levels to increase significantly in every quartile and for the distribution of minority students in each quartile to more closely reflect the student population as a whole. Thus, an important question for the education community is, What is the state of mathematics achievement at the elementary and secondary levels in the United States?

The intent of this paper is to begin to address this question. More specifically, the purpose of this report is to document changes in U.S. mathematics achievement during the 1980s and 1990s by reviewing national trend studies, college admissions examinations, and advanced placement tests. Relevant national trends in mathematics achievement from earlier periods will also be discussed. This report examines the quantitative research literature to determine trends in the mathematics achievement of various social groups defined along lines of race, class, gender, ethnicity, and language proficiency.

Other scholars have conducted similar analyses of mathematics achievement. For example, Lockheed, Thorpe, Brooks-Gunn, Casserly, and McAloon (1985) examined gender and racial-ethnic differences in middle school mathematics achievement. Their major findings included that little prior research had directly addressed either gender differences within ethnicity or gender-ethnicity interactions or had examined the factors that are related to achievement of girls of color in grades 4-8. Moreover, Lockheed and colleagues (1985) found that racial-ethnic, not gender, differences in mathematics achievement were more pervasive. Also, they noted that most of the empirical studies of achievement were focused on affective factors, rather than on policy-oriented factors such as coursetaking and bilingual education.

Secada (1992) examined the mathematics achievement of diverse groups along lines of race, ethnicity, social class, and language proficiency with one focus of the review directed to address the question, Has the mathematics achievement gap between White and minority students been closing? He found the data on whether the gap is narrowing mixed. Secada reported that the mathematics achievement gap appeared to be narrowing for African American students only and only on items that reflect low-level and basic skills mastery. Secada remarked that this was a

story of incomplete success, insofar as basic computational skills are not deemed sufficient for "true knowledge and mastery of mathematics" (p. 630).

Secada (1992) concluded that studies he reviewed indicate a relationship between a student's language proficiency and performance on measures of mathematics achievement. Specifically, Secada's review indicated that, while significant, correlations between language proficiency and mathematics achievement range between .20 and .50, with most being at the lower end of the scale. Thus, there was much variance to be explained.

Another important finding from Secada's (1992) review was that middle-SES and upper-SES students enter school with higher achievement levels in mathematics than lower-SES students. Moreover, the review indicated a consistent pattern of disparities in mathematics achievement and growth that is related to student SES. However, Secada (1992) noted that SES-based differences were greater among Whites than among African Americans or Hispanics in studies that established racial/ethnic groups and regressed achievement on a set of variables that included SES as a predictor.

The 1995 National Science Foundation report *Indicators of Science and Mathematics Education* reviewed mathematics achievement trends from the NAEP, college entrance examinations (ACT and SAT), and NELS:88. The report concluded that, over the past 15 years, U.S. students have earned higher scores on multiple measures of mathematics achievement. Further, during this time period, the differences among the scores of students from various races and ethnic backgrounds have narrowed; however, African American and Hispanic students continue to be outperformed by White and Asian students. In addition, the mathematics achievement differences between male and female students on the NAEP and NELS:88 test were small. However, males scored significantly higher on the ACT and SAT.

Leder (1992) conducted a review of the literature on gender and mathematics that included studies of gender differences in mathematics achievement. Leder reported that few consistent gender differences in mathematics achievement exist at the early primary level. However, this trend changes at the beginning of secondary school, and males frequently, though not always, perform better on standardized measures of mathematics achievement. According to Leder, gender differences depend on the content and format of the assessment administered, the age level at which testing takes place, and the cognitive level of the test questions.

This report will uniquely contribute to the important reviews on mathematics achievement of diverse groups conducted by Lockheed and colleagues (1985), Secada (1992), the National Science Foundation (1995), and Leder (1992) in several ways. First, this review will provide a more recent update of national mathematics achievement trends from NAEP, NELS:88, and follow-up studies linked to NELS:88. Second, demographic trends on SAT, ACT, and AP examinations are central in this review, whereas only one of the aforementioned major reviews of achievement and student performance in mathematics included the SAT and ACT examinations as part of their analyses (National Science Foundation, 1995).[1] However, the National Science Foundation report did not include AP examinations, and the NELS:88 analysis was limited to one study. This review provides a more comprehensive examination of the NELS:88 studies of mathematics achievement. Third, the conceptual focus of this report will

include both achievement differences across social groups and within-group changes in achievement over time. Three of the four previous reviews largely focused on gender and racial-ethnic achievement differences. The National Science Foundation (1995) report was the exception.

The first major section of this report is a review of general mathematics achievement trends. The intent of this section is to provide an overview of mathematics achievement trends in the United States. The second section examines the literature on mathematics achievement by diverse groups—race, class, gender, and language proficiency. The final section highlights important findings and describes policy-related implications.

Some General Trends for the Nation

General trends for mathematics achievement in the United States will be reported from several sources, including the NAEP, SAT, ACT, Advanced Placement calculus examinations (AB & BC tests), and NELS:88 studies. This section highlights the overall state of mathematics achievement as reported by the these data sources without specific focus on the performance of various social groups.

NAEP Trends

The findings from the six NAEP trend assessments provide important insight into how students' mathematics proficiency has changed during the period from 1973 to 1992. NAEP mathematics proficiency scores are available for 1973, 1978, 1982, 1986, 1990, and 1992. Tests are administered to a sampling of students from across the country at ages 9, 13, and 17. The scale, which ranges from 0 to 500, provides a common metric for analyzing levels of proficiency across assessments and demographic characteristics. NAEP scores also reflect student performance at five levels on the scale: Level 150—Basic Arithmetic Facts, Level 200—Beginning Skills and Understanding, Level 250—Basic Operations and Beginning Problem Solving, Level 300—Moderately Complex Procedures and Reasoning, and Level 350—Multi-Step Problem Solving and Algebra.

Overall, 9-, 13-, and 17-year-old students' average mathematics proficiency has improved in the 19-year history of the NAEP. According to Mullis et al. (1994), at age 9, average performance remained at a constant level of 219 from 1973 through 1982, then increased to 222 in 1986 and remained constant at 230 in 1990 and 1992. At age 13, average performance increased from 266 in 1973 to 273 in 1992. At age 17, the average performance decreased between 1973 and 1982 from 304 to 298. However, this trend has changed, and average performance increased in 1986, 1990, and 1992 to 302, 305, and 307, respectively.

Trends in mathematics proficiency by quartiles on the NAEP provide another important indicator of academic progress (Mullis et al., 1994). At all three ages, across each quartile, students significantly increased performance between 1978 and 1992 (Mullis et al., 1994). Results by quartile are not available for the 1973 NAEP. At age 9, after a period of no change between 1978 and 1982, students in all quartiles showed significant progress over the ten year span from 1982 to 1992. For example, students in the lowest quartile improved performance from an average of

178 in 1978 to 190 in 1992. Similarly, students in the highest quartile improved performance from an average of 256 in 1978 to 266 in 1992. Overall, the average performance increased approximately 10 to 12 scale points across each quartile of the age 9 distribution between 1978 to 1990, with improvement gains leveling off between 1990 and 1992 (Mullis et al., 1994).

For 13- and 17-year-old students, the most dramatic improvement since 1978 was for students in the lowest quartile (Mullis et al., 1994). At age 13, average performance steadily increased from 221 in 1978 to 236 in 1992. At age 17, average performance increased 10 scale points from 260 in 1978 to 270 in 1992. Also, between 1978 and 1992 average performance of age 13 and 17 for the middle two quartiles improved 8 and 6 scale points respectively. The age 13 average performance increased from 266 in 1978 to 274 in 1992. Age 17 average performance improved from 338 in 1978 to 342 in 1992. The average performance of the highest quartile at age 13 and 17 improved less than the other portions of the distribution, with age 13 increasing from 305 to 309, and age 17 from 338 to 342 over the period from 1978 to 1992 (Mullis et al., 1994).

NELS:88 Trends

Along with NAEP, two longitudinal cohort studies—High School and Beyond (HS&B) and the National Education Longitudinal Study of 1988 (NELS:88)—measured how students' mathematics performance changed during the decade of the 1980s. Rock, Owings, and Lee (1994) reported data from NELS:88 and the first follow-up surveys comparing changes in mathematics proficiency levels experienced by students as they progressed from eighth to tenth grade. The proficiency levels formed a hierarchial scale with each succeeding level more complex. Thus, a proficiency at higher levels implies proficiency at the lower level. The four levels were defined as follows:

> Level 1—Students are able to perform simple arithmetic operations on whole numbers.
> Level 2—Level 1 proficient as well as performance on simple arithmetic operations with decimals, fractions, and roots.
> Level 3—Level 2 proficient as well as successfully solving simple problem tasks that require conceptual reasoning and/or the development of a solution strategy.
> Level 4—Level 3 proficient as well as successfully solving more complex problems.

Rock and colleagues (1994) reported that more than half (54.6 percent) of the sampled eighth graders were classified at Level 1 or below. A little over one in five eighth graders (23.3 percent) were classified at Level 2, and the remaining 22.1 percent were Level 3 proficient. Two years later, in 1990, these same students were assessed, and almost two-fifths (38.1 percent) of the tenth graders were classified at Level 1 or below. Another 14.7 percent were reported at Level 2 proficiency. Nearly one-quarter (24.7 percent) were classified at Level 3 proficiency, and the remaining (22.5 percent) were reported at Level 4.

Hoffer, Rasinski, and Moore (1995) analyzed data from the second (1992) follow-up survey of the NELS:88. All of the students in their analysis were eighth graders in 1988. Eighty-five percent of the students were high school seniors when the data were collected in 1992. Hoffer and colleagues (1995) reported that the average number of mathematics courses (Carnegie units) completed in high school was 2.8 (sd = 1.3). The average achievement gain for the cohort over

the four-year period was 11.6 scale points. Moreover, students who completed more mathematics courses showed greater achievement gain from the end of eighth to the end of twelfth grade. Students who completed no courses, one course, two courses, three courses, four courses, and five or more courses gained on average 5.6, 6.1, 8.6, 11.0, 14.4, and 15.4 points respectively in their mathematics achievement score.

Rasinski, Ingels, Rock, and Pollack (1993) compared the mathematics achievement of 1980 and 1990 sophomore cohorts from the HS&B and NELS:88 respectively. Overall, the HS&B mean test score was 32.81, the NELS:88 mean was 35.97, and the effect size .26. The effect size of .26 is the difference between 35.97 and 32.81 which is 3.16, divided by the total standard deviation from 1980. The .26 effect size indicated, that on average, the sophomore students in 1990 were performing 26% of a standard deviation higher that their comparable cohort in 1980.

College Entrance and AP Examinations

Scholastic Aptitude Tests (SAT) provide another measure of quantitative reasoning skills. The mean score on the mathematics section of the SAT declined 26 points—492 to 466—from 1967 to 1981 (College Board, 1993a). Since 1981, the mean mathematics score has risen slowly, with the 1995 mean score of 482 still 10 points below the 1967 mean (College Board, 1995).

Grissmer, Kirby, Berends, and Williamson (1994) compared the change in SAT scores with the change in NAEP scores for 17-year-old students over the period from 1973 to 1990. The overall national mathematics trend for the NAEP and SAT scores were marginally different, with the SAT slightly down and NAEP sightly up, and the difference being about .1 standard deviation.

Like the SAT, the ACT provides an indicator of achievement for students planning to attend college. The average mathematics score on the ACT has remained relatively constant—20—between the 1989-90 school year and the 1994-95 school year (ACT, 1991, 1995). The average mathematics score for students who reported completing a core college preparatory curriculum deviated only sightly from the 1994-95 mean of 21.5 during this six-year period. More importantly, this average score remained constant during a six year period of expansion when the number of students who reported completing the core college preparatory curriculum (four courses including trigonometry) increased by 43% from 370,379 in 1989-90 to 529,146 in 1994-95. In contrast, the number of students who reported completing less than the core college preparatory curriculum decreased by 8.5 percent from 394,540 to 360,925 in 1989-90 and 1994-95, respectively. The average mathematics score for students with less than the core college preparatory coursework remained at or near 18.3 from the 1989-90 school year to the 1994-95 school year.

The College Board's Advanced Placement (AP) calculus exam provides another indicator of national achievement. In a four-year period, from 1991 to 1994, the number of students taking the AP calculus AB and BC examinations increased by 29 percent and 24 percent respectively (College Board, 1991, 1994).[ii] The average score on the AB examinations increased from 2.93 in 1991 to 3.03 in 1994. Similarly, the average score on the BC examinations increased from 3.56 in 1991 to 3.71 in 1994. The AP grading scale for both examinations is as follows: 5 = extremely well qualified, 4 = well qualified, 3 = qualified, 2 = possibly qualified, 1 = no recommendation.
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Summary

The NAEP trend analysis indicates improvement across assessments in each age group (Mullis et al., 1994). Moreover, at all three ages, improvements occurred in each quartile between 1978 and 1992. The NAEP trends are relatively consistent with findings from NELS:88 assessments and SAT trends in mathematics.

Rasinski et al. (1993) reported on a comparative analysis using HS&B and NELS:88 data that indicated that sophomores in the U.S. gained in mathematics achievement between 1980 and 1990. Also, Rock and colleagues (1994) reported on the NELS:88 assessment and the 1990 follow-up survey: 57.6 percent of the sample performed at a higher proficiency level in the tenth grade than in eighth grade; nearly one-third (32.9 percent) of the sample remained at the same proficiency level; while less than 1 in 10 (9.6 percent) devolved.

Another important indicator of achievement is the dramatic increase in numbers of students who have taken the SAT, ACT, and AP calculus exams. Moreover, this increase in student participation has been coupled with a constant or positive trend in test scores. These increases should be interpreted as an overall improvement in national mathematics achievement.

Findings suggest that, overall, students in the United States are slowly improving their mathematics proficiency. However, what is not clear from this general trend analysis is which subgroups are remaining at the same proficiency level, which are regressing, or which are progressing.

Racial and Ethnic Trends

In 1990, the percents of African American, Native American, Asian, and Hispanic children 18 or younger were 14.6, 1.1, 3.2, and 11.7, respectively (Riche & Pollard, 1992). According to the National Science Foundation (1994), these racial/ethnic groups make up 22 percent of the total labor force; they were 14 percent of the science and engineering labor force in 1990. Many demographic studies suggest that the racial and ethnic diversity of the U.S. is growing (e.g., Riche & Pollard, 1992; Vernez, 1992). This growth and a changing political climate have made it more difficult to classify racial/ethnic groups. For example, the Hispanic, Asian, and African American populations each include many distinct subgroups; most of the literature on mathematics achievement is not at this level of detail. Recognizing this limitation, it is still instructive to review this literature for current mathematics achievement trends.

NAEP Trends

The racial and ethnic trends in mathematics achievement on the NAEP improved between 1973 and 1992. The level of improvement varied greatly across race/ethnicity. In the 1992 NAEP, for 9-, 13-, and 17-year-old Whites, average proficiency scores in mathematics were 235, 279, and 312; for African Americans, respective scores were 208, 250, and 286; and for Hispanics, they were 212, 259, and 292 (Mullis et al., 1994).

Overall, at ages 9, 13, and 17 between the test years 1973 and 1992, White students increased their average mathematics proficiency by 10, 5, and 2 scale points; for African American students, respective gains were 18, 22, and 16; and for Hispanic students, they were 10, 20, and 15 (Mullis et al., 1994).

The differences in average mathematics proficiency on the NAEP of students at ages 9, 13, and 17 between 1973 and 1992 are graphically presented in Figure 1 for White and African American students and Figure 2 for White and Hispanic students. The trendlines that overlie the data indicate two broad phases for differences in average proficiency of White and African American students at ages 9 and 13 (see Figure 1). The first phase, from 1973 until 1986, featured a moderate decrease in average proficiency difference. However, after 1986, the difference in average mathematics proficiency increased slightly. The difference in mathematics proficiency of African American and White students at age 17 slightly decreased from 1973 until 1990. However, the difference increased between 1990 and 1992.

The difference in average mathematics proficiency on the NAEP of White and Hispanic students at age 9 has remained relatively constant—between 20 and 23 scale points—from 1973 to 1992. Figure 2 indicates at ages 13 and 17 two phases for differences in the average proficiency of White and Hispanic students. The first phase, from 1973 to 1986, was a period of gradual decrease in average proficiency difference. The difference in average proficiency increased between 1986 and 1990 then decreased between 1990 and 1992.

Several mathematics reform documents have called for more instructionally relevant assessment instruments that provide insights into mathematical problem solving ability (NCTM, 1989, 1991, 1995; NRC, 1993). The 1992 NAEP mathematics assessment at grades 4, 8, and 12 introduced a new format: extended-response questions allowed students approximately five minutes to

demonstrate—in writing, by giving examples, or by drawing diagrams—their problem solving abilities (Dossey, Mullis, & Jones, 1993). The extended-response items were not classified by mathematics content domain because they generally crossed domains. Dossey reported for grade 4 that the average percentage of White, African American, and Hispanic students who scored a satisfactory or better on extended response items were 20, 5, and 7 respectively; for grade 8, respective average percentages were 10, 2, and 3; and for grade 12, average percentages were 10, 4, and 4.

NELS Trends

Rasinski and colleagues (1993) contrasted mathematics scores for sophomores in the 1980 HS&B and 1990 NELS:88 (a follow-up conducted in 1990), via a scaling procedure that linked the two assessments. Asian sophomores averaged 38.82 and 40.26 on the 1980 HS&B and 1990 NELS:88 common scales, respectively; for White sophomores, the respective means were 35.41 and 37.96; for Hispanics, 25.96 and 30.75; and for African Americans, 24.51 and 28.74. Rasinski et al. (1993) reported that all racial/ethnic groups, with the exception of Asian students, made statistically significant gains in mathematics achievement. Both Hispanic and African American students gained more than Asian and White students. In terms of effect sizes, the gains were .12, .21, .39, and .35 for the Asian, White, Hispanic, and African American students respectively. The achievement gap between Hispanic and White students and African American and White students was reduced during the 1980s. More precisely, the achievement gap between Hispanic and White students in 1980 was .77 of the 1980 total standard deviation while the corresponding gap in 1990 was .59 of the 1990 total standard deviation. Similarly, comparative figures for the African American and White students indicated that the achievement gap went from .89 of a standard deviation in 1980 to .75 of a standard deviation in 1990 (Rasinski et al., 1993, p. 24).

Hoffer et al. (1995) reported on the relationship between the number of mathematics courses that high school students of different racial backgrounds completed and their achievement gain from the end of grade 8 to grade 12. The scale used in this study was the number of items a student answered correctly on the mathematics cognitive tests administered in the spring 1992 survey, when most students were in grade 12. The sample standard deviation of the mathematics test was 14.1. Overall, Hoffer and colleagues indicated the average grade 12 achievement test scores in mathematics for Asian, Hispanic, African American, White, and Native American students were 53.36, 41.69, 39.23, 49.84, and 39.25, respectively. The average mathematics achievement gains over the four-year period of high school for Asian, Hispanic, African American, and White students were 13.8, 11.1, 9.6, and 11.9 scale points respectively. No data were given for Native Americans. Hoffer et al. indicated that, when African American and White students who completed the same number of courses were compared, the difference in average achievement gains was smaller, and none was statistically significant. Similarly, the Asian-White mathematics achievement gains were also generally reduced among students completing the same number of math courses. The exception was that the Asian advantage over Whites among students completing four courses was about the same as the overall gain differential.

Green, Dugoni, Ingels, and Camburn (1995) reported findings from the NELS:88 Second Follow-up survey that included an exam of mathematics achievement by seniors in 1992. Green and colleagues defined five levels of mathematics proficiency:

Below Level 1:	Unable to perform simple arithmetic operations.
Level 1 (low):	Able to perform simple arithmetical operations on whole numbers: single step operations.
Level 2:	Simple operations with decimals, fractions, powers, and roots.
Level 3:	Simple problem solving of low level mathematical concepts.
Level 4:	Understanding of intermediate level math concepts and/or demonstrating the ability to formulate multistep solutions to word problems.
Level 5 (high):	Able to solve complex multistep word problems and/or the ability to demonstrate knowledge of mathematical principles found in advanced mathematics courses.

Students classified at Level 4 or 5 were considered advanced proficiency. Green et al. found that African Americans and Hispanics were less likely than White and Asian students to demonstrate advanced proficiency on the standardized test of mathematics (12 percent and 20 percent compared to 39 percent and 45 percent respectively). Moreover, 50 percent of the African American and 42 percent of Hispanic students were classified at the low proficiency level or below. In comparison, 14 percent of the Asian and 21 percent of White students performed at low proficiency or below.

College Entrance and AP Examinations

The AP calculus examinations are an indicator of mathematics achievement because they document the number of students advancing to—in most cases—the highest level of mathematics coursework offered in the United States K-12 system. For this portion of the analysis the AB calculus advanced placement examination is the focus. The reason for selecting the AB calculus test is that more students take this examination than the more advanced BC calculus examination. For example, 5 times as many students took the AB exam as the BC exam in 1994 (College Board, 1994). In 1994, 89,954 students were administered the advanced placement AB calculus exam. White, Asian American, Chicano/Mexican, and African American students were 67 percent, 15.7 percent, 2 percent, and 4 percent of the candidates, respectively. Native American and Puerto Rican students were each well under one-fourth of one percent of the total candidate pool. These figures are not very positive. However, another method to analyze the AP calculus exams is within-group participation and performance over time. Specifically, two groups, African American and Chicano/Mexican, provide insight.

The positive increase in AP calculus participation has included African American and Chicano/Mexican students. The number of African American and Chicano/Mexican students scoring a 3 (qualified) or above is one indicator. For example, in 1990, 939 African American students took the BC calculus examination and 458 (48.7%) scored a 3 or better (College Board, 1990a). In comparison, in 1994, 3509 African American students completed the BC examination with 1264 (36%) scoring a 3 or better (College Board, 1994). In 1990, 595 Chicano/Mexican students took the BC calculus examination and 363 (61%) achieved a 3 or better (College Board, 1990a). For the 1994 BC examination, 1837 Chicano/Mexican students completed the exam and 815 (44%) scored a 3 or better (College Board, 1994).

The ACT is another indicator of mathematics achievement. The ACT introduced a new mathematics test in 1990. Thus, comparisons with earlier years are impossible. On the 1995 ACT mathematics section, the mean scores of students from various races and ethnic groups ranged widely below the maximum score of 36. The mean mathematics score for Asian, White, Mexican American/Chicano, Puerto Rican, Native American and African American students were 22.8, 20.7, 18.6, 18.7, 18.1 and 16.8 respectively (ACT, 1995). From 1992 to 1995 the mean mathematics scores of Asian students have been higher than the mean scores of White students, and the mean scores of all other minority groups were lower than scores of White students (ACT, 1992, 1993, 1994, 1995). However, additional insight into the between group achievement gap is provided by examining within-group trends.

The 1995 ACT mean mathematics scores for Asian, White, Mexican American/Chicano, Puerto Rican, Native American, and African American students who completed core college prep courses in mathematics were 23.7, 22.1, 18.8, 19, 19.2, and 17.8, respectively (ACT, 1995). Between 1992 and 1995 the percent of Asian, White, Mexican American/Chicano, Puerto Rican, Native American, and African American students taking the ACT who completed core mathematics courses increased by 29, 21, 5, 93, 34, 37, respectively (ACT, 1992, 1993, 1994, 1995).[iii] Moreover, the mean mathematics scores for students completing the core mathematics courses by ethnic group have remained relatively constant during this period.[iv] This is a positive indicator of greater mathematics achievement across ethnic groups.

Between 1987 and 1995 the mean score on the mathematics section of the SAT increased for students from all races and ethnic groups (College Board, 1995). For example, the mean mathematics scores of White, Asian, Mexican American, Puerto Rican, Native American, and African American students increased 9, 17, 2, 11, 15, and 11 points respectively (College Board, 1995). However, large gaps remain between students of various races and ethnic groups on the SAT.[v]

Socioeconomic Trends

Intellectual domains in the social sciences approach the conceptual definition of social class in various ways (Knapp & Woolverton, 1995). While all build on the economic roots of class, they give different interpretations and, in varying degrees, link to the term other cultural, political, and social meanings. Typically the mathematics achievement literature is organized according to a hierarchy of classes—working class, lower-middle class, middle class, and so on. This hierarchy often objectifies high, middle, and low positions on some metric such as socioeconomic status (SES). For a discussion of the limitations of this practice see Knapp and Woolverton (1995), Grant and Sleeter (1986), and Secada (1992).

NAEP Trends

For the 1978, 1982, 1986, 1990, and 1992 NAEPs, Mullis et al. (1994) provided trends in average mathematics proficiency by the highest level of education that students reported for either parent: less than high school education, graduation from high school, some education

beyond high school, and graduation from college. For each year of NAEP testing, the difference separating the average proficiency of 9-, 13-, and 17- year-old children of parents with some education after high school and children of college graduates ranged between 1 and 12 scale points in favor of the latter (500-point scale). During the same testing periods, at each age level, the difference between children reporting their parents' highest level of education as a high school graduate versus some education beyond high school ranged from 7 to 15 scale points. Similarly, the difference in average proficiency between children of parents with less than a high school education versus high school graduate ranged between 5 and 19 scale points. The relationship between parents' highest level of education and students' average mathematics proficiency was most obvious when comparing students whose parents were college graduates or completed some education after high school versus students whose parents were not high school graduates. From 1978 to 1992, at each age level, the difference in average mathematics proficiency in favor of the first two categories versus the latter ranged from 19 to 39 scale points. However, 9- and 13- year-old students whose parents did not complete high school experienced the greatest increase in average proficiency from 1978 to 1992—17 and 11 scales points respectively.

Another indicator of student SES (or social class) is the type of community in which the student lives. In the 1978, 1982, 1986, 1990, and 1992 NAEPs, for all ages (9, 13, and 17) the average mathematics proficiency of students from extreme rural communities was higher than students from disadvantaged urban communities, and students from advantaged urban communities had the highest average mathematics proficiency (Mullis et al., 1994). Advantaged urban communities are defined as cities with a population greater than 200,000 where a high proportion of residents are in professional or managerial positions (Smith et al., 1995). Disadvantaged urban communities are defined as cities with a population greater than 200,000 where a high proportion of residents are on welfare or not regularly employed (Smith et al., 1995).

NELS Trends

In their longitudinal study comparing sophomore cohorts from the HS&B 1980 and 1990 NELS:88 follow-up, Rasinski et al. (1993) documented a consistent pattern of growth in mathematics achievement and difference that is related to student SES. Four SES groups were formed by dividing the socioeconomic status composite into SES high quartile, SES high-middle half, SES low-middle half and SES low quartile. The findings are presented in Table 1. Initially it would appear that the highest quartile gained more than the lowest quartile; however about 12 percent of the lowest quartile in 1990 were missing mathematics scores while almost all the 1980 lowest quartile had mathematics scores. Rasinski and colleagues conjectured that the lowest quartile gain could be biased downward as a result of missing scores. Thus, any interpretation of differential gain between quartiles would be problematic.

TABLE 1
Mathematics Scores of Sophomore Cohorts from the HS&B 1980 and 1990 NELS:88 Follow-up, by SES

	HS&B 1980	1990 NELS:88

	Mean	Mean	Effect Size
SES High	39.53	42.90	.27
SES High Middle	34.58	37.15	.21
SES Low Middle	31.65	34.10	.20
SES Low	26.73	29.17	.18

Source: Rasinski et al. (1993)

Hoffer et al. (1995) examined the relationship between the number of mathematics courses that high school students of four SES levels completed and their achievement gain in high school from 1988 to 1992. Overall, Hoffer and associates indicated the average grade 12 mathematics achievement test scores for students in the SES low quartile, SES low middle-half, SES high-middle half, and SES high quartile were 38.88, 44.69, 49.07, and 55.83 respectively. The average mathematics achievement gains during the four years of high school for students classified in the low quartile, middle quartiles, and high quartiles were 9.7, 11.4, and 13.4 scale points respectively. Hoffer et al. reported that none of the SES comparisons showed significant differences among students taking the same number of courses. They interpreted this finding to mean that much of the SES difference in mathematics achievement in grades 9-12 is the product of the different numbers of mathematics courses that high and low SES students complete during secondary school.

Green et al. (1995) reported findings from the 1992 NELS:88 Second Follow-up survey of seniors. Green and colleagues examined the relationship between demonstrated proficiency at various levels of mathematics by various demographic characteristics including SES and parents' education. High SES students were less likely than Medium SES and Low SES students to be classified at the low proficiency level or below (8.6 percent compared to 25.1 percent and 46.1 percent respectively). The percents of High SES, Medium SES, and Low SES high school seniors who demonstrated the two highest mathematics proficiency levels were 57.2, 32.2, and 14.6, respectively.

Green et al. (1995) found a strong relationship between parents' education and the demonstrated mathematics proficiency of the 1992 high school seniors. The classifications for parents' education were Less Than High School, High School Graduate, Some College, Completed

College, and Graduate Degree. In order, students demonstrating low mathematics proficiency or below were 51.9%, 43.1%, 25.7%, 14.6 percent, and 8.3 percent. Moreover, the percents of children of parents with a graduate degree, college degree, some college, high school graduate, and less than high school who demonstrated the two highest proficiency levels were 59.4, 45.9, 30.9, 22.5, and 10.8 respectively.

Green and colleagues (1995) also compared achievement across racial and ethnic groups, controlling for SES. Table 2 presents data on the mathematics proficiency of Asians, Hispanics, African Americans, and Whites controlling for SES. The two lowest proficiency levels--Below Basic and Level 1--and the two highest proficiency levels—Levels 4 and 5—are contrasted. From these data, it is apparent that some achievement differences persist, even when the effects of social class are held constant. For example, Green and colleagues reported that, within each SES group, significant differences existed between Whites' and African Americans' test performance. Also, significant differences exist between Hispanic and White seniors in the high SES group. Differences between Asian and White seniors' performance were generally not significant.

College Entrance Examinations

In 1990, 41,845 (5%) of the students taking the SAT reported a family income of less than $10,000 per year (College Board, 1990b). The mean SAT mathematics score for this group of students was 419. In that year, the largest percentage (19%) of students reported family income of between $30,000 and $40,000 per year and obtained a mean mathematics score of 469. A little over 150,000 students (17%) reported family income in the highest category of $70,000 or more. The mean mathematics score for students in this category was 527. From 1990 to 1995, there was a positive relationship between students' reported family income level and the SAT mean mathematics score. Moreover, the mean mathematics score across family income levels remained relatively constant over this time period. Between 1992 and 1995 a similar trend exists for the mathematics portion of the ACT.

TABLE 2
Mathematics Proficiency by Race, Controlling for SES
Percentage of 1992 High School Seniors

SES	Below Basic or Level 1	Levels 4 or 5
Low		
Asian	26.2	22.7
Hispanic	51.4	12.5
African American	60.4	4.9
White	40.2	18.3
Middle		
Asian	15.1	40.7
Hispanic	35.0	25.3
African American	44.9	15.6
White	21.7	34.9
High		
Asian	8.1	64.7
Hispanic	16.6	43.8
African American	26.3	26.5
White	7.7	58.9

Source: Green et al. (1995)

In 1992, 33,489 (4%) of the students taking the ACT indicated a family income of less than $6000 per year, and the mean mathematics score for this group was 17.4 (ACT, 1992). Twenty percent or 165,964 of the students reported a family income between $30,000 and $41,999 and obtained a mean mathematics score of 20.7. The highest income category of $60,000 and over consisted of 17% of the students; they had a mean score of 22.4. From 1992 to 1995, as for the SAT, a positive relationship existed between the reported family level of income and the ACT mean mathematics score (ACT, 1992, 1993, 1994, 1995). Similarly, the mean mathematics scores across family income levels have changed very little during this time.

Gender Trends

The purpose of this section is to review the literature on gender and mathematics achievement. Men and women constitute 48.8 and 51.2 percent of the U.S. population respectively. Women make up approximately 46 percent of the labor force and 22 percent in science and engineering related fields (NSF, 1994). More specifically, in 1990, women were 9 percent of the engineers, 35 percent of the mathematicians and computer scientists, and about 51 percent of the social scientists. These demographic data provide a backdrop for exploring K-12 gender-related mathematics achievement trends.

NAEP Trends

Mullis et al. (1994) reported trends in average proficiency in mathematics by gender. The long-term gains in mathematics by gender were inconsistent between 1973 and 1992. At age 9, the average mathematics proficiency for males and females improved significantly between 1973 and 1992, but a plateau in gains between 1990 and 1992 was observed for both genders. The average mathematics proficiency for 9-year-old males improved 13 scale points from 218 in 1973 to 231 in 1992; and for females, the respective average proficiency scores were 220 and 228. For 13-year-olds, males' average mathematics proficiency increased 9 scale points from 265 in 1973 to 274 in 1992; for females, the respective averages were 267 and 272. For 17-year-olds, males' average mathematics proficiency fluctuated down from 309 in 1973 as many as 7 scale points in 1986 back to 309 in 1992. Seventeen-year-old females' average mathematics proficiency improved 3 scale points from 301 in 1973 to 304 in 1992.

NELS:88

Rock et al. (1994) reported changes in mathematics proficiency levels between eighth and tenth grades, by gender and mathematics course-taking pattern. Data were obtained from the 1988 base year and 1990 first follow-up surveys of National Education Longitudinal Study. Overall, 60.7 percent of the males and 54.5 percent of the females performed at a higher proficiency level in tenth grade than in the eighth grade. However, when course-taking patterns were analyzed, this trend was not consistent across all groups. Specifically, no difference was found between male and female students who were enrolled in either (1) Algebra only (48.7 percent versus 42.6) or (2) Trigonometry/Precalculus/Calculus (71.1 percent versus 69.9 percent). For two other classifications (1) no Algebra (41.3 percent versus 28.3 percent) and (2) Geometry/Algebra II (73.1 percent versus 66.5) a difference in favor of males was found.

Rock and Pollack (1995) reported data from NELS:88 that documented growth in mathematics achievement during the high school years and its relationship to differential course-taking in mathematics. Figures 3 and 4 present mathematics gains for five course-taking categories of male and female students respectively.

The stacked histograms illustrate the students' eighth-, tenth-, and twelfth-grade scores by the highest course level taken in high school. Inspection of the total columns indicates, that on average, both male and female students made greater gains in achievement between the eighth and tenth grade than between tenth and twelfth grade for material covered by the NELS:88 mathematics tests. Rock and Pollack (1995) found that gains for the two groups were quite similar during this time period. However, males showed slightly more improvement in scores than did females between 10th and 12th grade, resulting in greater gains over the four year interval for males. Figures 3 and 4 indicate that, even before entering high school, male and female students who would ultimately enroll in more advanced coursework already had substantially higher average math achievement scores than students who did not complete advanced mathematics courses. Moreover, male and female students who enrolled in more advanced coursework had greater gains in achievement over time than students who ultimately enrolled in lower level courses.

Rasinski and colleagues' (1993) longitudinal study comparing sophomore cohorts from the HS&B 1980 and NELS:88 1990 follow-up documented a similar pattern of growth in mathematics achievement that is related to student gender. Female sophomores averaged 32.60 and 35.89 on the 1980 HS&B and NELS:88 common scales, respectively (.27 effect size); and for male sophomores, the respective means were 33.02 and 36.06 (.27 effect size). Rasinski et al. found that the difference between the two gender groups in the relative amount of gain achieved was not significant. That is, the amount of gain was the same for male and female students of the 1990 sophomore cohort.

Hoffer et al. (1995) examined high school students' coursetaking and achievement in mathematics by using data from the NELS:88 second follow-up transcript survey. The purpose of the study was twofold. The first purpose was to document overall achievement in mathematics and science. The second purpose was to analyze the effects of coursework on the students' proficiencies within the domains of mathematics and science. Hoffer and colleagues reported that the average grade 12 achievement levels for male and female students were 48.23 and 47.08 respectively. The male-female difference in mathematics achievement (1.15) was not statistically significant at the conventional $p = .05$ level. Overall, the average achievement score gains in mathematics for male and female students during high school were 12 and 11.1, respectively. Both males' and females' average test score gains from grade 8 to grade 12 were greater the more courses they completed. Moreover, both male and female students benefited about equally from additional coursework.

College Entrance and AP Examinations

The number of male and female students taking the AB and BC Advanced Placement (AP) calculus examinations increased each year between 1991 and 1994 (College Board, 1991, 1992, 1993b, 1994). The number of male students taking the AB and BC examinations in 1991 was 38,980 and 9,137 respectively; and the number of female students was 30,616 and 4,627 respectively (College Board, 1991). In 1994, the number of males taking the AB and BC examinations was 47,953 and 10,934 respectively; and the number of females was 42,001 and 6,190 respectively (College Board, 1994). Male students taking both versions of the AP calculus examination consistently outnumbered female students during this period. However, the

percentage difference between male and female examinees has declined each year from 27 percent and 97 percent more males taking the AB and BC examinations in 1991 to 14 percent and 77 percent in 1994.

The average scores for male and female students increased on both the AB and BC exams from 1991 to 1993 (College Board, 1991, 1992, 1993b). The average scores on the AB examination for male students between 1991 and 1994 were 3.07, 3.16, 3.20, and 3.12 respectively; for females students respective scores were 2.76, 2.93, 2.98, and 2.93 (College Board, 1991, 1992, 1993b, 1994). The average scores on the BC examination for male students during this same period were 3.66, 3.73, 3.58, and 3.82; for females students respective scores were 3.35, 3.39, 3.32, and 3.50. However, the average score for male students was greater than female students between 1991 and 1994 on both the AB and BC examinations. The difference in average score was slowly closing on the AB examinations; however, the gender difference on the BC average scores remained relatively constant during this period.

In 1995, the mean ACT mathematics scores and standard deviations for males and females were 20.9 (SD=5.1) and 19.7 (SD=4.6) respectively (ACT, 1995). The 1995 mean scores and standard deviations are consistent with ACT profiles for male and female students in prior graduating classes (i.e., ACT, 1992, 1993, 1994). Similarly, females score significantly lower than their male counterparts on the mathematics section of the SAT (NSF, 1995). For example, in 1995, the mean score for all females taking the SAT was 40 points lower than the mean score of males—463 versus 503 (College Board, 1995). From 1967 to 1995 the male mean mathematics score was at least 40 points greater than the female (College Board, 1990b, 1995).

Language Proficiency

There is very little research on language proficiency and mathematics achievement trends. Further complicating matters are the conceptual arguments related to language proficiency in the broader research literature. During the past twenty years, the term Limited English Proficient (LEP) has been used to describe students acquiring English. Recently, some scholars have argued that the term LEP supports a discourse of student deficiency (Casanova & Arias, 1993; Secada, 1996)--a discourse that could limit opportunity to learn in mathematics. It is with this warning in mind that the literature on language proficiency should be reviewed. Most of this literature builds on the discourse associated with LEP.[vi] Only one study was relevant to this review.

Bradby (1992) examined the demographic and language characteristics of Asian and Hispanic eighth graders and related that information to their mathematics test scores on the NELS:88 survey. After defining themselves as Asian or Hispanic, students were asked to specify their ethnic subgroup (e.g., Mexican or Korean). Also, students were classified as Language Minority (LM) or Limited English Proficient (LEP). Language minority refers to students who live in homes where a non-English language is spoken. The English skills of language minority students range from fluent in English to not being able to speak English at all. Limited English Proficient defines children with sufficient difficulty with English that they are educationally disadvantaged

in classes taught only in English. This category was divided into three subgroups—Low, Medium, or High English Proficiency.

Bradby (1992) further categorized the LM and LEP students into four mathematics performance levels: basic, intermediate, advanced, and below basic. At the basic level, the student is proficient with arithmetic operations on whole numbers. At the intermediate level, a student can complete operations with decimals, fractions, percentages, and roots. At the advanced level, students are capable of completing intermediate tasks and can also perform problem solving including geometry and simple equations. Students performing below the basic level have not mastered any skills in the previous levels.

Bradby (1992) indicated that the percentages of LM students who self-reported as Mexican, Cuban, Puerto Rican, and other Hispanic who were unable to attain the basic mathematics proficiency level were 35, 34, 42, and 37 respectively. The relationship between the ethnic subgroup of Hispanic LM students and their achievement on the math test was not significant.

Overall, Bradby (1992) reported that the same percentage of Hispanic LM and non-LM students were unable to achieve the basic level in mathematics (about 36 percent). This result remained even when controlling for SES.

However, proficiency in English language among Hispanic LM students was strongly related to mathematics achievement. According to Bradby (1992), as English proficiency increased, the percentage of those who failed to achieve the basic mathematics level decreased. Specifically, 58 percent of the low English proficient Hispanic students failed to achieve the basic level of mathematics performance, compared with 37 percent of the moderately proficient and 35 percent of the highly proficient. These estimates of the relationships between English proficiency and underachievement were adjusted to control for SES.

Bradby (1992) indicated that the relationship between SES and mathematics achievement persisted among Hispanic students even when English proficiency was held constant. For example, among LM eighth graders with high English proficiency, 40 percent of the low SES LM students failed to achieve at the basic math level as compared to 24 percent of high SES LM students. Similarly, among LM eighth graders with moderate English proficiency, 40 percent of the low SES LM students failed to achieve at the basic math level compared to 31 percent of the high SES LM students. Almost 60 percent of the low SES LM eighth graders with low English proficiency did not achieve at the basic math level. No comparison was possible between low SES and high SES students with low English proficiency because the total number of students in the former category was too small.

Bradby (1992) reported that the percentages of Pacific Islander, Filipino, Japanese, Chinese, Southeast Asian, Korean, and South Asian LM eighth graders unable to achieve the basic mathematics level were 43, 29, 21, 21, 15, 18, and 16, respectively. However, due to small sample sizes, these differences were not statistically significant. Overall, nearly the same percentage of Asian non-LM and LM students were unable to achieve the basic level in mathematics (27 percent and 23 percent, respectively). Moreover, the relationship between English proficiency and a failure to achieve the basic math level was not significant among

Asian LM students. Estimates of the relationships between language proficiency and underachievement were adjusted to control for SES.

Bradby (1992) indicated that a greater proportion of Asian students with higher SES than with lower SES achieved above the basic level in mathematics. The percentage of low SES, middle SES, and high SES Asian eighth graders unable to achieve at the basic mathematics achievement level was 39, 25, and 14 respectively.

Discussion

Between 1980 and 1995, racial-ethnic, SES, and language proficiency differences in mathematics achievement were more pervasive than gender differences. This finding is consistent with findings from previous research on mathematics achievement (Lockheed et al., 1985). However, Lockheed and colleagues' review was limited to middle school students. In contrast, studies reviewed in this report included elementary, middle, and secondary students.

The differences among the scores of students from various races and ethnic groups have slowly narrowed; however, African American and Hispanic students continue to perform at significantly lower levels than White and Asian students. This finding is consistent with reviews conducted by Secada (1992), Lockheed and colleagues (1985), and NSF (1995).

Secondary students of every racial-ethnic and SES group benefited from additional mathematics coursework in high school. Moreover, students completing the same number of mathematics courses did not have significant differences in achievement. The importance of this finding is that policy can be used to intervene. One method of intervention is to mandate specific course requirements at the secondary level. To enhance this policy intervention, additional support for student learning is required at the elementary level. What is clear from the studies reviewed is that elementary school mathematics achievement is positively related to secondary school achievement. Thus, mandating more secondary courses without systemic efforts to change elementary school mathematics experiences and achievement levels is potentially problematic.

Males tended to outperform females on standardized measures of mathematics achievement; however, gender differences were small and generally not significant. The most significant gender differences occurred on more advanced level mathematics assessments. For example, males consistently outperformed females on college admissions and advanced placement calculus examinations. This finding supports Leder's (1992) review of the literature on gender and mathematics achievement. Leder noted that gender differences depended on the format, age level, and cognitive level of the test. Findings from this review suggest that male and females students perform very similarly on assessments of basic mathematics skills. Differences were more pronounced on assessments requiring complex mathematical reasoning. This interpretation is weakened by the fact that students taking college admissions tests, and to some extent advanced placement tests, are self-selected samples.

A limitation of many of the studies reviewed for this report is that the data were not organized in a way to examine two or more demographic variables. Future research on mathematics

achievement should move in this direction. The complexity of demographic groups warrants more integrative analysis.

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Endnotes

1. The SAT and ACT are limited as indicators of mathematics achievement. The sample of students taking the test is not representative of any particular sample of students in the United States. Each year the sample changes in composition and size. In general, these changes have resulted in a downward bias in test score trends (Grissmer et al., 1994).

1. The total numbers of students in 1991 taking the advanced placement AB and BC exams were 69,596 and 13,764 respectively.

1. The numbers of White, Mexican American/Chicano, Puerto Rican, Native American, Asian, and African American students completing core mathematics courses and taking the ACT in 1995 were 388,505; 13,435; 13,585 ;5,398; 19,237; 48,097 (ACT, 1995).

1. The exception was Puerto Rican students who experienced a significant one-year (1994 to 1995) increase (56%) in students categorized as completing the core mathematics. During this one-year period, scores for students in this category declined from 20.4 to 19.

1. For example, in 1995, the mean mathematics scores of White, Asian, Mexican American, Puerto Rican, Native American, and African American students were 498, 538, 426, 411, 447, and 388 respectively (College Board, 1995). The highest possible score is 800.

1. Secada (1996) stated,

> At a time when the country's educational systems are challenged to produce an informed citizenry who can participate in an increasingly multicultural and multilingual society and who can help that society in a technological and economic world that includes diverse peoples, a new term is arguably needed to communicate the potential resources that are represented by students who, in addition to knowing language(s) other than English, are acquiring English. (p. 443)

Secada argued that LEP should be replaced by Students Acquiring English.

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